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DISPLAY APPARATUS

The invention relates to a display apparatus having a display layer and a touch-sensitive layer running parallel thereto.

Such display apparatuses are used when it is necessary not only to display information graphically but also to use the apparatus for input. Such a display apparatus is useful particularly when using graphical user interfaces for operating systems or application programs. In these cases, functions are activated by buttons, in which case either the buttons can be clicked on with a cursor, for example using a mouse, or else the appropriate function can be activated by touching the display apparatus directly. Such display apparatuses are often called touchscreens.

Since such display apparatuses are able to save an input unit, display apparatuses of this kind are used in preference for small portable appliances, for example "handhelds" or PDAs. Particularly in mobile operation, however, the problem arises that there is a relatively high level of ambient brightness, and reflections appear on the display apparatus which significantly impair the legibility of the display apparatus.

From cathode ray tube units, where the problem of reflection likewise arises, it is known practice, in order to avoid reflections on the screen surface, to arrange a lattice in front of the screen, this usually being a fine-meshed wire netting, and this means that although displayed information can still be easily seen by an observer, obliquely incident ambient light can no longer cause any reflections.

In touch-sensitive display apparatuses, such wire netting or a similar apparatus cannot be used, because the relatively rigid structure means that even touching it with a relatively pointed object such as a pen would result in a broad pressure area, which can result in incorrect inputs. Even when the touch-sensitive layer has a high resolution, precise work is no longer possible.

Another known possibility for avoiding disruptive reflections is to roughen the surface pointing in the direction of an observer by starting to etch it, for example. A drawback of this solution is that the scatter effect does not just affect incident ambient light, but rather likewise affects the light which individual pixels on the display layer emit and scatter, and hence the sharpness of the image is reduced.

It is therefore an object of the invention to specify a display apparatus which has a touch-sensitive layer and which nevertheless has protection against surface reflections from ambient light.

The invention achieves this object by means of a display apparatus of the type mentioned at the outset which is characterized in that that side of the touch-sensitive layer which is remote from the display layer has an antireflection lattice comprising lattice elements which can move toward one another. The object is likewise achieved by a display apparatus of the type mentioned at the outset which is characterized in that that surface of the touch-sensitive layer which is remote from the display layer has a lattice-like surface texturing, the lattice spacing being matched to the pixel spacing on the display layer such that the

ratio of the lattice spacing to the pixel spacing is even-numbered.

The even-numbered ratio of the lattice spacing to the pixel spacing ensures that the light emitted by pixels on the display layer is not scattered, but rather reaches the observer directly. The lattice forms more or less microscopic channels. Obliquely incident light, on the other hand, is reflected or absorbed by the lattice elements.

The object is likewise achieved by a display apparatus of the type mentioned at the outset which is characterized in that the touch-sensitive layer contains lattice elements, the lattice spacing being matched to the pixel spacing on the display layer such that the ratio of the lattice spacing to the pixel spacing is even-numbered.

In the case of such an embodiment, the lattice elements which prevent reflections have already been integrated into the touch-sensitive layer. A fourth way of achieving the object is for the touch-sensitive layer in a display apparatus of the type mentioned at the outset to be formed by strip-like lattice elements arranged in lattice form, and for touch sensors to be integrated into the nodes of the lattice. In such an embodiment, the touch-sensitive components and the antireflection components are not separate units, but rather the same elements perform functions both for avoiding reflections and for producing the touch sensitivity.

In a display apparatus of the type mentioned at the outset, it is advantageous if the lattice elements are of strip-like design, the lattice elements being able to move toward one another at nodes of the lattice. The

strip-like configuration ensures a good antireflection behavior.

It is particularly advantageous if the angle between the lattice elements and the touch-sensitive layer is adjustable. The lattice elements mean that the viewing direction parallel to the lattice elements is highly preferable to an oblique viewing angle. A changeable angle between the lattice elements and the touch-sensitive layer allows the preferred viewing direction to be adjusted in line with the user's wishes.

Another advantageous configuration of the first solution provides for the antireflection lattice to be removable. In the case of the third solution mentioned, where the touch-sensitive layer contains lattice elements, it is advantageous for the lattice elements to have liquid crystals. This means that the antireflective behavior can be turned off and turned on when necessary.

The latter solution advantageously provides for electrical conductors running parallel to the display layer to be integrated into the lattice elements and for the lattice elements to be made of an elastic material, with means being provided for evaluating capacitive, inductive or resistive characteristic values for two electrical conductors from different lattice elements.

Further advantageous configurations of the invention are specified in the subclaims.

The invention is explained in more detail below with the aid of exemplary embodiments. In the figures:

Figure 1 shows a PDA with a display apparatus based

on the invention,

Figure 2 shows a schematic illustration of a first exemplary embodiment of a display apparatus based on the invention,

Figure 3 shows a three-dimensional illustration of lattice elements from the exemplary embodiment in Figure 2,

Figures 4 to 6 show variants of the embodiment of lattice elements,

Figure 7 shows a further exemplary embodiment with the touch-sensitive properties integrated into the lattice elements,

Figure 8 shows a display apparatus based on the invention with a removable antireflection lattice,

Figure 9 shows the arrangement from Figure 8 with a removable antireflection lattice,

Figure 10 shows a display apparatus based on the invention with controllable lattice elements.

Figure 1 shows a PDA (Personal Digital Assistant) 11 with a display apparatus 1 based on the invention. The display apparatus 1 is of touch-sensitive design and, to this end, has a touch-sensitive layer 3. In the symbolic illustration in figure 1, there is also an antireflection lattice 4 which is suitable for eliminating disruptive reflections.

Figure 2 shows the display apparatus from figure 1 in a

more detailed illustration. As can be seen from figure 2, the antireflection lattice 4 comprises a multiplicity of lattice elements 5. These are at a predetermined angle 9 on a touch-sensitive layer 3. Preferably, the angle 9 is 90°. The lattice elements 5 form microscopic channels 10 through which an observer looks onto the touch-sensitive layer and onto the display layer 2 underneath. In order for good visibility to be ensured, the lattice elements 5 are thus oriented parallel to the viewing direction 12. Incident light 18 from the side is absorbed by the lattice elements 5 and as a result only a small proportion thereof reaches the at least partially reflective surface of the touch-sensitive layer 3 or of the display layer 2.

Particularly in the case of small portable appliances such as the PDAs shown in figure 1, it is easy to hold the appliance respectively such that the viewing direction is at right angles to the display apparatus 1. In the case of larger appliances such as Notebooks or permanently installed flat screens, however, it is not always possible or not always easy to orient the display apparatus 1 with respect to the user in optimum fashion. It is therefore advantageous if the lattice elements 5 are not rigid but rather are able to move such that their angle 9 with respect to the touch-sensitive layer 3 can be altered. In the case of an embodiment with an adjustable angle for the lattice elements, optimum orientation can be achieved by means of user setting or automatically on the basis of the incident ambient light. To this end, by way of example, a sensor may be provided which measures the angle of incidence of ambient light and uses appropriate control apparatuses to actuate the lattice elements 5 such that they are at an optimum angle.

The lattice elements 5 are either partially transparent or nontransparent. To attain a satisfactory action, the material of the lattice elements 5 should be light-absorbent or should form a light-absorbent surface.

For the quality of the display apparatus 1, it is necessary for the lattice spacing between lattice elements 5 to be matched to the pixel spacing of the pixel elements 8 on the display layer 2. Otherwise, the "Moiré effect" may arise. This occurs when odd-numbered spacing ratios mean that lattice elements 5 are situated above pixel elements 8 in particular regions, while in other regions the lattice elements 5 are situated precisely between two pixels. The Moiré effect can be avoided if the ratio of lattice spacing to pixel spacing is even-numbered. In figure 2, the lattice spacing has been chosen such that it is twice the size of the pixel spacing. Two pixels 8 therefore have one lattice element 5.

Figure 3 shows a three-dimensional schematic illustration of the arrangement of the lattice elements 5. The lattice nodes 13 are each in a form such that slots in the strip-like lattice elements 5 ensure that the lattice elements are flexible with respect to one another. This is important so that pressure on the lattice elements 5 is respectively transferred to the underlying location on the touch-sensitive layer 3.

Figures 4 to 6 show alternative configurations of the antireflection lattice 4. In the illustration in figure 4, studs are provided at the lattice nodes 13. This stud-like configuration ensures a very beneficial transfer of force to the touch-sensitive layer 3. If the studs are of an appropriate size and the lattice spacing is correspondingly small, an adequate antireflection action can be produced.

In figure 5, there are likewise strip-like lattice elements 5, these being interrupted completely at the nodes 13. The width of the strips 5 can be reduced further, and hence it is not necessary for the strips to extend over the entire length between two nodes 13.

In the illustration in figure 6, there are bristle-like lattice elements 7. Such an embodiment of the lattice elements is suitable, above all, when the ratio of the lattice spacing to the pixel spacing is much greater than 1. In one configuration of lattice elements, in which only the lattice nodes 13 permit a touch to be detected, the resolution of the touch-sensitive layer 3 would therefore be very low. However, since each bristle is able to transfer a force exerted on it from above, it is possible to attain a good touch resolution even with a large lattice spacing.

In the embodiment in figure 7, the functions of the touch-sensitive layer 3 and of the antireflection lattice 4 have been combined with one another. This is achieved by virtue of the lattice element 15 not only being of strip-like design, in order to develop an antireflection action, but rather also being touch-sensitive. This is achieved by virtue of the lattice elements 15 containing electrical conductors 14 which do not touch at the nodes 13 (this cannot be seen in figure 7). The specific evaluation of individual electrical conductors 14 means that it is possible to evaluate a change in the spacing between two electrical conductors 14 at individual nodes 13. This is because a change results in capacitive, inductive or resistive values changing. To this end, the lattice elements 15 need to be elastic so that the exertion of a pressure also results in a change in the spacing between two conductors.

Another possible way of combining the antireflection function and the touch sensor function is to use lattice elements such as those shown in figure 5, for example, and additionally to set up touch sensors at the nodes. This can be done merely by using a capacitively sensitive sensor element, for example, which is respectively arranged at a node 13. Capacitive sensor elements work by virtue of an object brought close altering the electrical field, which results in a change of capacitance for an electrode which represents the sensor element. This change of capacitance can now be evaluated.

Figure 8 shows the possible way of connecting the antireflection lattice 4 pivotably to a housing which holds the touch-sensitive layer 3 and the display layer 2. In this way, the display apparatus can also be used without an antireflection lattice 4.

Figure 9 shows a similar configuration to that in figure 8, but the reflection lattice 4 can be mounted instead of being arranged pivotably on the housing. Positioning pins 16 ensure that the antireflection lattice is positioned such that the lattice elements do not disturb the light radiated by pixel elements on the display layer 2.

Figure 4 shows an embodiment of a display apparatus based on the invention in which lattice structures have been incorporated into the touch-sensitive layer 3. In this case, the lattice elements do not need to be flexible. In this case, the lattice elements 17 do not need to be flexible. The lattice elements may also be made of liquid crystals or of an electrochromic material. In this case, the lattice elements can be turned on or off as required by applying an appropriate

control voltage. So as not to impede the display properties of the display layer, the lattice spacing should also be matched to the pixel spacing in this case.

When liquid crystal antireflection lattices are used, the optical orientation of the lattice elements can be adjusted by applying an appropriate control voltage. In this case, the adjustment can be made either manually by the user or automatically on the basis of the level and/or angle of incident ambient light.

List of reference numerals

1	Display apparatus
2	Display layer
3	Touch-sensitive layer
4	Antireflection lattice
5	Lattice element (strip)
6	Lattice element (stud)
7	Lattice element (bristle)
8	Pixel
9	Angle
10	Microscopic channel
11	PDA
12	Viewing direction
13	Lattice node
14	Electrical conductor
15	Combi lattice element
16	Positioning pins
17	Lattice elements